TOOL-USING BY BIRDS AND RELATED BEHAVIOUR

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Introduction

The answer to the question "How many bird species use tools?", in **A new dictionary of birds** (Thomson, 1964) was: **One**. "The fully authenticated instance is that of one of the Geospizinae of the Galapagos Islands, *Camarhynchus pallidus* [now *Cactospiza pallida*], which has the habit of using a spine or small twig, held in the bill, as a probe in search of insect prey." The purpose of this contribution is to bring together scattered references to tool-using by birds, some in the wild, some in captivity, in the hope of stimulating interest in the readers of Avicultural Magazine.

Thomson defined tool-using as "actually wielding some external object as an implement". Of tool-using among animals generally, Hall (1965) wrote "Tools and weapons have been described as extra-corporeal limbs", which can be changed or discarded as circumstances dictate. Essentially an animal's performance may be defined as 'tool-using' if it takes hold of some object in its hands, claws, jaws, beak or trunk, and then proceeds to use that object as a kind of extension of its own. body to reach something it could not otherwise reach, break open only at the risk of damaging its teeth, or to repel something threatening or alarming". In her review of tool-using in primates and other vertebrates, Jane van Lawick-Goodall (1970) says that "a tool-using performance in an animal or bird is specified as the use of an external object as a functional extension of mouth or beak, hand or claw, in the attainment of an immediate goal. This goal may be related to the attainment of food, care of the body, or repulsion of a predator, intruder, etc."

It might be supposed that these definitions would be simple enough to apply when asking whether any particular piece of avian behaviour constituted tool-using. But disagreements between authors show that it is not so simple (Chisholm 1954, 1969, 1971a, 1971b, and 1972; Thorpe 1956; Millikan and Bowman 1967; Lawick-Goodall 1970). The fact is that birds use and manipulate objects and materials in a variety of ways. Some of their actions we may choose to call tool using but the distinction is not a hard and fast one. A quick, but wide-ranging review of avian object-and materials -use will demonstrate.

Outline of general object- and materials-used by birds

To begin with some of the more obvious examples, birds pick up and often manipulate their food items with the bill or feet. They drink water and other fluids. They turn their eggs, sometimes carry their young, and usually remove faeces and egg-shells from the nest. Many birds use water or dust for bathing and a few use substances cosmetically. A number of species use extraneous objects in displays both sexual and intimidatory. Birds build nests using a multitude of matter, often very skilfully; no human has ever built a bird's nest as well as a bird. Some birds, notably crows, parrots and birds of prey "play" with objects, and a few species repeatedly drop them, apparently for the enjoyment of the sound effects. At least two fish-eaters attract their prey with specially positioned baits or lures. Many passerines use ants and other objects apparently to rid themselves of ectoparasites, and at least one hole-nesting bird rubs the rim of its nest entrance with insects leaving a repellent substance. Mainly among captive species, but also in the wild, birds have been observed using inanimate items in body care. There are two possible instances of an object being used aggressively: as a missile and a lance.

To return to feeding behaviour and some of its more sophisticated expressions, there are birds that scratch away earth or leaves, birds that flip stones out of the way in foraging, and others that hollow out a "vice" in which to hold food. There are those that impale prey on thorns or lodge it between forked branches (these instances are not strictly relevant but both have been considered to be tool-using in the past). Certain birds will pull up food suspended in air at the end of a string; two members of the crow family are known to pull up fishing lines suspended through holes in the ice. There are birds in at least four families that drop hard-shelled items from a height to break them open, and representatives of at least three families use anvils for a similar purpose. Three or more avian species hurl objects as missiles or use the same objects as hammers when attacking thick-shelled food items. Lastly, several birds wield sticks, twigs, spines or pieces of bark to assist in food-gathering. I will enumerate all behaviour that has been, held by any author to be tool-using, or that seems to be worthy of consideration as such. But in summing up I shall select and tabulate only the more obvious and acceptable cases.

Borderline cases in wild and some captive birds

As will have been clear from the latter part of the preceding summary, the variety of behaviour patterns that writers have been tempted to class as tool-using is considerable, and demonstrates "that tool-using is not the only kind of activity in birds which establishes complex relationships between objects" (Millikan and Bowman 1967). They referred specifically to the Tailorbird *Orthotomus sutorius* of south-east Asia that stitches leaves together with plant fibres to form a receptacle for its nest, but which can hardly be classed as a true tool user. The impaling of prey on thorns by many of the shrikes (Laniidae) is well known. Other birds store food in the forks of branches in trees and shrubs; and several other birds may use spines or forked sticks to anchor a carcase while they flay it with the bill (Millikan and Bowman 1970). These authors conclude that "This is an example of a fixed device which serves as an extension of the body, in this case, talons" and is thus a true form of tool-using. Lawick-Goodall (1970) on the other hand concluded that the use of fixed skewers is not true tool- using because the thorn (or whatever) is not manipulated by the bird. Similarly, she rejected the suggestion by Lancaster (1968) that the nest-building activities of both birds and mammals were examples of tool-using. Nor is it easy to accept A. Kortlandt's suggestion (pers. comm.) that the vice-hollowing abilities of woodpeckers (Picidae) amount to tool-using. Examples include the Spotted Woodpecker *Dendrocopus major* which shapes a "vice" in which to wedge a pine cone as illustrated in the film "Carpenters of the Forest" and the attendant book (Sielmann 1958): and the Lewis's Woodpecker *Asyndesmus lewis* which makes a "chopping block" by removing the bark or part of a tree and wedging acorns in the resulting depression (Law 1959), It is, after all, by the same process that the woodpecker hollows its nest hole The Baya Weaver *Ploceus philippinus* can be trained by Indian entertainers to use a needle and thread in a remarkable manner. A tethered bird of this species is illustrated in Fisher and Peterson (1964), the painting being based on a film by T. H. Work. The bird, rewarded with millet, has learnt the trick of threading 8—10 beads on to an 8-inch tasselled cord. The 3-inch needle is held 1/2 -inch from the tip for best control. The dexterity displayed by the bird in performing this trick is no more than re-application, or a refinement of certain nest-building actions. It is difficult to regard this trick, or indeed even the most complex nest material manipulation by weaver birds (Ploceidae) as anything more than the use of materials, albeit with very sophisticated relative positioning. Crook (1960) showed that some African weavers can tie half-hitches round stems with blades of grass.

A North American Sandhill Crane *Grus canadensis* kept captive by Des and Jen Bartlett (1973a and b), appeared to use a towel to dry itself after bathing. They described how the crane would swim behind a canoe "and then after flapping his wings use a towel to dry himself off for half an hour. He would drop the towel many times during this performance, but he persisted, rubbing it carefully around his legs and toes and under his wings". It would be interesting to know whether this bird behaved in this way only when it was wet. To have offered it non-absorbent material of about the same size, shape and colour as the towel might have been a valuable experiment. However, it seems more likely that the Bartletts were seeing an abnormal version of a wild behaviour pattern well established in cranes. They dig up and rub soil over their feathers. Many of the greyish species of cranes thus acquire a brownish or reddish stain over their entire body; giving them a much better protective coloration (Walkinshaw 1973). That birds use inanimate objects in apparent "play" is well-established For example, there was a succession of notes in British birds journal (McKendry 1973, and references therein) concerning Herring, Common and Black-headed Gulls, *Larus argentatus*, *L. canus* and *L. ridibundus* Common and Sandwich Terns, *Sterna hirundo* and *S. sandvicensis*, and the Hooded and Carrion Crows, *Corvus corone corone* and *C. c. cornix*, many of them playing in flight with such items as stones, sticks, leaves, by letting them go and catching them again before they reached the ground. Similar behaviour by a Lammergeyer *Gypaetus barbatus* was witnessed in Africa (Huxley and Nicholson 1963). Almost all birds known to drop hard-shelled food objects to smash them open are either larids, corvids or accipitrids (see following paragraphs). Did aerial playfulness with objects follow or precede the more functional behaviour? In other words did the dropping of food items lead to play with comparable objects, or was play the means by which birds discovered a new way of obtaining food? A more likely explanation is that in carrying food from where it was caught to where it was to be consumed, the accidental dropping of items on suitable terrain could have led to the establishment of the habit.

Birds also appear to play with objects on the ground. A game of "tag" by White-winged Choughs, involving a small stick or a bunch of grass, was described by Chisholm (1948) and the same writer (1971b) instances Rainbow Birds *Merops ornatus* seen to toss shiny pebbles into the air. Brown and Amadon 1968 described the mid-air and terrestrial antics of a Prairie Falcon *Falco mexicanus* with a piece of dried cow dung. A thorough search of the literature would, no doubt, reveal many more examples of avian object-play.

Lawick-Goodall 1970 gave an instance of stone-dropping by a pair of Black Kites *Milvus migrans* which could be play. "One bird picked up three stones in its talons, one after the other, flew some fifty yards with them, and dropped them at about 5-minute intervals: the second picked up and dropped two stones. All five stones were dropped from a height of about 60 feet. Unfortunately the observer, one of our assistants, did not immediately investigate: subsequently we found four of the five stones within an area of some five square yards at the bottom of a shallow grassy gully among some low bushes. We could rind no indication as to why they and been dropped, but the behaviour was probably connected with feeding, as the birds showed no aggressive diving or screaming during the performance."

Hard-shelled food items are dropped by many birds. The Lammergeyer is known to drop mammalian bones and at least one species of tortoise Boswall and Crook 1968, Hartley 1964. A number of crows of the genus *Corvus* release from a height various molluscs, sea urchins, crustaceans, and also a species of tortoise. Gulls the world over (mainly of the genus Larus) also drop molluscs, echinoderms, and crustaceans and anurans; also birds' eggs, and there is at least one record of Antarctic Skuas *Catharcta skua* dropping penguin eggs (Sladen 1958). But none of these birds count as tool-users, nor can the birds that beat hard prey against "anvils" of stone or other materials. These include the Song Thrush *Turdus philomelos*; certain of the pittas (Pittidae), e.g. the Buff-breasted Pitta *Pitta versicolor*; the Stagemaker *Scenopoeetes dentirostris* (Hartley 1964); and the White-winged Chough Corcorax melanorhamphus (Hobbs 1971 ; Chisholm 1971b).

Four instances were quoted by Hartshorne (1973) involving as many species and a larger number of individuals of songbirds (Oscines) playing at sound-making by dropping objects from their bills or pushing them off the top of a house or desk. The performances were repeated again and again and the birds gave signs of listening for the sounds as a 'reward' Comparable behaviour by Galahs *Eolophus roseicapillus* which are said to have frequently dropped stones on to the iron roof of a country house in New South Wales is reported by Chisholm (1971a). The same writer quoted a report of about thirty "Magpies" (sp.?) that dropped stones on to a rural rooftop. It was said that this action was taken only on mornings when a delay had occurred in the regular practice of putting out food for the birds.

Antes (1948) has recorded how Gila Woodpeckers *Centurus uropygialis* fed their chicks by a somewhat sophisticated means. "When parent Gila Woodpeckers *Centurus uropygialis* virtually gorged their young with thick, granulated honey that was placed in a saucer on a sycamore stump, I thinned the honey to the consistency of syrup. Not so easily scooped, the liquid was fed by the male parent in a clever manner. He gouged pea-sized lumps of bark from the stump, dipped them in the syrup, and gave the honey-coated pellets to his fledglings. He repeated this trick for many days, sometimes varying it by using grains or sunflower seeds which were in a hollow of the same stump."

Thorpe (1951, 1956) described as an elementary form of tool-using the ability of a number of species, e.g. tits (Paridae) and Jays *Garrulus glandarius*, to pull up food suspended on a thread. Though not meeting Thomson's definition, Millikan and Bowman (1967), who undertook string pulling experiments of their own, considered it constituted tool-using apparently on the grounds that the birds swallow the food but not the string and thus can apparently distinguish between the two objects. However, the same two authors challenged Thorpe's tentative acceptance of two bird species, the Tailorbird (Wood 1936) and the Little Spiderhunter *Arachnothera longirostris* (Whelford 1916), that use spiders' lines as thread as "tool-users".

Similarly Lawick-Goodall (1970) in her review of tool-using in primates and other vertebrates did not consider the two birds mentioned by Thorpe as tool-users, and she makes a clear and useful distinction between "tools" and "materials". She further considered that string-pulling behaviour is a skilful manipulation of objects rather than tool use: "The string and food lure form a visual continuum and, in pulling on the string, the animal is merely pulling at a part of the food". In the following otherwise comparable case, however, the line and the food do not form a visual continuum! In Scandinavia Hooded Crows, and in one instance a Raven *Corvus corax* pulled up fishing lines suspended through holes in the ice and consumed any hooked fish (Holmberg 1957). Lone crows would take hold of the line near the hole, walk away with a loop for a certain distance before turning and walking back on top of the line to prevent it slipping, before taking another hold and repeating the process. In two instances two or more crows co-operated in the hauling up of the tackle.

The dexterity of tits is readily demonstrated by their string-pulling performances, and an example that also comes very close to tool-using is quoted and discussed by Thorpe (1945).

"Mr. Trevor Miller, of Riding Mill, Northumberland, in several letters, described in full and exact detail how in 1938 when a boy, he had suspended a conical tit-bell of the usual type 3 ins. in diameter half filled with fat. A fine string was hung centrally through the fat, its end 4 ins. below the rim of the bell. To this end of the string a light stick of balsa wood 4 ins. long and 5 in. thick was suspended, tied firmly by its middle. The second day after this apparatus was put up, one or more Blue Tits, failing to reach the fat by any other means, landed on the bar and, hanging in an inverted position, rolled it up the thread with rapid movements of the feet and so reached the fat. This process was seen "once or twice a day for several weeks" and it is thought that more than one bird was concerned. Mr. Miller has, I understand, since repeated the experiment without success. That such an achievement could have been an example of "'insight learning" I do not for a moment believe, but I think some subsequent observations by myself and my friend Mr. T. C. Wyatt in Cambridge suggest how it might have come about. Having fitted up an apparatus similar to Mr. Miller's, I found that unless the bell was composed of some extremely hard, smooth substance wood, glass, bakelite and metal bells were all tried; both Great and Blue Tits were able to hang or. to the edge. If this mode of access was denied them they climbed up the string even though it was well greased. If fine silk or cotton thread was used they were unable to do this and then the results were very instructive. The varied resources and "ingenuity" displayed by Blue Tits in reaching the fat was astonishing. Some would manage to pull themselves up the thread parrot-wise with beak and foot sufficiently well to make a rapid stab at the fat before falling off. Others would hover below and make quick upward darts at the food, securing a beakfull each time. If the string was not too long others would straddle with one foot on the string and the other braced against the bar and so, with effort, would lever themselves up until just within reach. Yet others would stand on the bar and with a rapid stepping movement execute little fluttering jumps carrying the bar a little way with them. None succeeded in rolling the bar up the string, but I think this last performance shows how a bird such as a tit ('a bird which is in any case habitually hanging from twigs and righting itself might accidentally roll the bar up a little way. Having done so we may be sure that such a rapid learner, as this species is, would perceive the advantage and repeat the process."

This behaviour is not tool-using in the strictest sense, because the "tool" (the stick and the string) was not used as an extension of the bird's body and actually brought to bear on anything solid.

In his book *I, the aborigine*, Lockwood (1966) wrote of kite hawks—or fire hawks as they were known to the indigenous people—that Chisholm (1971a) took to be Black Kites *Milvus migrans*. After outlining how these birds take advantage of prey flushed out by bush fires he says that they deliberately set fire to grass and bushland. "I have seen a hawk pick up a smouldering stick in its claws and drop it in a fresh patch of grass half a mile away then wait with its mates for the mad exodus of scorched and frightened rodents and reptiles. When the area was burnt out the process was repeated elsewhere". This statement and some attendant details make convincing reading but in the absence of accounts by critical observers the case must remain unproven.

K. E. L. Simmons has suggested to me that active (or direct) anting in which passerine birds pick up one or more ants and apply them to the underside of the wing, might be considered a form of tool-using—especially as the behaviour seems connected with feather care, i.e. by killing ectoparasites with formic acid (Simmons 1906). However, I think the birds are better considered as using materials than using tools, though it is admittedly a borderline case. Simmons also drew my attention to the "bill-sweeping" behaviour of White-breasted Nuthatches *Sitta carolinensis* studied by Kilham (1968, 1971): these birds rub insects and other items-piant material, fur, and (once) a feather—on the bark near their nests However, insects seem to be the primary objects used and Kilham suggests that the behaviour functions to spread repellent substances from the crushed insects in the area of the nest-hole in order to divert or distract tree squirrels. The sweeping objects are often stored both before and after use. Again, I find it difficult to regard this as true tool-using.

Another example of bird behaviour, while perhaps not strictly tool-using: is so closely related that it is worth mentioning in detail. This is the baiting or luring of fish by wild Green Herons *Butorides* *virescens* and in captive Sun Bittern *Eurypa helias*. Lovell (1958) described how wild Green Heron in Florida, fed bread by humans, would place the bread in the water. Fish would thus be lured, which the heron then caught and consumed. Lovell wrote: "A clear indication that the Greer. Heron knew what he was doing was furnished by the following incident. While he was standing by some floating bread, several small fish broke the surface of the water several feet to his left. The heron immediately became excited, picked up his bread and moved it to almost exactly the same spot where the fish had appeared". Lovell suggests originally that the bird first noticed that bread thrown into the water attracted fish, "then having learned to associate bread with fish, went one step further and learned to place bread in the water." Exactly comparable behaviour by another Heron near the Miami Seaquarium, also in Florida, has been reported. The account, by Sisson (1974) is illustrated with colour photographs. The author was told by a Captain Charles Buie that "The bird has a mother and a brother that also fish with pellet bait..." and that on one afternoon within a 25 minute period a bird was seen to bait and catch two dozen fish —missing on only two occasions. Again in Florida, Norris (1975) saw a Green Heron using an object as a lure. The bird was in immature plumage and the "bait" was a feather. A series of photographs show how the bird patrolled a ditch, feather in bill, before pausing, deliberately dropping the "fly" into the water and then catching a fish that had apparently reacted to the feather. A Sun Bittern captive in the tropical house of the Wildfowl Trust in Gloucestershire fed on live Swordtail fish in the ornamental pond. The bird appeared to fish by placing the tip of its bill in the water, an action that caused the fish to swim up, and grabbing one. Human visitors who place a finger in the water find that the fish crowd around as a food response. At a later stage the Sun Bittern would pick up maggots put out as food for passerine birds and place them in the water. To these the Swordtails were also lured and the Sun Bittern was thus able to capture them [L. P. Alder, pers. comm. 1974]

On 1st June, 1977, R. J. Prytherch (pers. comm.) watched a vagrant Squacco Heron *Ardeola ralloides* near Weston-super-Mare, England. While hunting the bird frequently caught flying or perched insects. After capture these were dipped in the wind-rippled water before ingestion— or so the observer thought at the time. Later, when the water was calm, it was clear that the heron was placing the invertebrates on the mirror-like surface. In twenty minutes sixteen insects were thus placed and one fish was caught. Whether the fish was attracted by the bait it is not possible to be sure, but it seems probable that the bird's behaviour was intended to have this effect.

True tool-users in captivity

Aviculturists are in a particularly favourable position to observe tool-using behaviour. Smith (1970, 1971 and pers. comm.) referred to a Bare-eyed Cockatoo (*Cacatua sanguinea*) which when offered a dead matchstick would hold it in his or her claws and quite deliberately, though admittedly with little facility, use it to scratch (poke might be the more descriptive word, the throat area immediately under and posterior to the base of the lower mandible ... I saw this bird, intermittently on and off for the three winter months of the year, and must have seen him "Chinese back scratch" the throat region some dozen or so times". I later spoke with the subsequent owner of this bird who told me it would sometimes scratch four or five times a day. Smith (op. cit.) gave four more instances of captive parrots using foot-held objects to scratch themselves. Two refer to individual Lesser Sulphur-crested Cockatoos *Cacatua sulphurea*, one in Cornwall and one in Bedfordshire; and two to African Grey Parrots *Psittacus erithacus*. Extracts from these four accounts are repeated here to encourage discussion. One of the Lesser Sulphur-crested Cockatoos used "A piece of stick, sometimes of some size, to scratch the sides and base his head (he is one of those unfortunate birds that has lost its plumage through the strange affliction that seems so common to the small white cockatoos) and though he has not much to scratch in the way of feathers the stick seems to have the right feeling for him and he obviously enjoys his loofah." The second Lesser Sulphur-crested "When given a piece of wood will bite it for a few minutes then will always scratch under its wings and on its head. It will do this for up to thirty minutes. It also likes to get a cigarette packet, or a monkey nut in the shell, and do the same thing." The African Grey Parrot extracts are as follows: "I heard him utter little 'clucks' and 'aahs' of pleasure. He hung to the vertical bars of his cage with one foot. In the other he held a cotton-bobbin which he was using as a back-scratcher." The second bird "Often uses a piece of twig to scratch his head and neck. I give him twigs daily off my apple tree and after he has stripped the bark he then goes through some antics which include his scratching with the twig." The reason for stripping off the bark is not clear.

J. P. Kruijt (pers. comm. April 1974) kindly sent me an account of his and others' observations on a solitary captive African Grey Parrot in the Netherlands, made in December 1961. "The parrot would hold the tea spoon close to the spatulate end, and poke the top and side of its head This behaviour could be elicited easily, simply by offering the spoon. The parrot would also accept a large spoon, but would drop it soon after some manipulation, apparently because it was too heavy. The owner constructed a new scratching instrument from a piece of wire, which was bent to form a loop on one end. The parrot would hold it at that end and scratch itself with the other end. The owner told me that it did this within a few minutes of its being presented with the spoon for the first time. It would also transfer this instrument via the bill to the other foot and then scratch the other side of the head. A veterinary surgeon, Mr. van der Kooi, visiting the family, made the following observation on the same parrot:' it picked up one of its own moulted loose tail feathers at the broad end scratched with the other end near its ear, over the top of its head, and even close to the ear on the other side'."

Taylor (1975) reported similar behaviour by two African Grey Parrots that frequently used a twig, piece of biscuit or a discarded feather held in the foot to scratch the back of the head and neck. Yet another bird of the species frequently used a spoon to scratch the back of its head (Judy pers. comm. April 1977).

D. A. Blanden (pers. comm., April 1977) reported that her Bluefronted Amazon Parrot *Amazona aestiva* used one of its chewing sticks to "brush and back comb" its head feathers.

Plath (1957) states "the ability of parrots to use tools deserves special mention. For example, one parrot used her perch to scratch her head, and another used a stick for this purpose".

The first of the two African Greys mentioned by Smith (1971) also succeeded in using a briar pipe to bale water out of his pot. The owner reporrted that the bird was "bought toys for his amusement. One of these was a brand-new briar pipe... He succeeded in bailing water out of his water pot by holding the stem in his beak, and dipping the bowl in the pot. Our parrot made this discovery whilst indulging in his favourite habit of 'dunking' hard objects".

A third (Staffordshire) Lesser Sulphur-crested Cockatoo was "First noticed using an almond shell for drinking water. She also regularly drinks from half a peanut-shell". It is evident that the bird was holding these objects in her foot, for the account goes on to describe how this three year old bird also used a teaspoon for baling water: "If she has the teaspoon the right way up she can drink from it". There is also the account of Porter (1936) whose Keas *Nestor notabilis,* if given a tin, would use it to bale out a container of water. "They have a large enamel tray for a bath which holds several gallons of water; this they have to empty with a cigarette tin or cup, each bird having a turn at baling out the water. Like children, they love to play about with water, and are never happier than when banging articles about in their water tray and making a splash." It would not seem from this account that the purpose of baling was to get at the water, thus the bird was not using the tin or cup as a mechanical means to an end. Rose Fyleman (1936) wrote "I should like to mention here that I once knew a cockatoo that would use the empty shells of monkey nuts to scoop up water when this was too low in his water pot to be within reach of its beak." Unfortunately it is not clear if this bird was using its foot or its beak. The phrasing suggests that the bird needed the water for drinking, and if this is so it is more like that the baler was held in the foot. A number of Northern Blue Jays *Cyanocitta cristata* raised and kept in a laboratory were observed tearing pieces from pages of newspapers and utilizing them as tools to rake in food pellets which were otherwise out of reach (Jones and Kamil 1973). The birds also employed twig-like objects for the same purpose. A second kind of behaviour that also purely constitutes tool-use was also reported for these birds. A jay several times took pieces of paper, dropped it in its water dish and swept it round its food cup picking up food dust as if with a sponge. The jay would then either eat the pieces of dust off the paper or ingest the paper itself. To the first kind of behaviour the authors applied the term "tool-making" (as well as tool-use). The paper is illustrated with frames enlarged from a 16mm film.

Goodman and Fisk (1973) in describing the breeding behaviour of captive Striped Owls *Rhinoptynx clamator* said "Small chicks, unsteady, may fall into the bloody carcasses of the chicken from which their food is coming. The female ... has been observed to gather pieces of dried leaves in her bill and use them to wipe the blood from both faces and breasts of the young".

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True tool-users in the wild

The best known and best studied example of an avian tool-user is the Galapagos Woodpecker Finch *Cactospiza (Camarhynchus) pallida* whose use of a cactus spine or twig was observed at least as early as 1901 by Rollo Beck (Bowman 1961) and was first reported by Gifford (1919). Subsequent students of this bird include Lack (1945, 1947), Eibl-Eibesfeldt (1961, 1964a, 1964b, 1967; Eibl-Eibesfeldt and Sielmann (1962 . Bowman (1961), Hundley (1963; and Millikan and Bowman (1967). The bird was filmed in captivity in West Germany by Sielmann (1964); and filmed under controlled conditions in the Galapagos by Joan and Alan Roots (see both Anon 1967 and Peterson 1967 for the Roots' excellent still photographs).

I can deal here only with a few of the more important aspects of the tool-using behaviour. From the English summary to Eibl-Eibesfeldt's 1961 paper, and from his brief, popular 1964 accounts, it is clear that when looking for prey: this species first searches like a true woodpecker, using its bill to prise off bark, thus uncovering insect holes. It will then pick up accessible prey directly with the bill. If no prey is accessible the bird then flies off to fetch a cactus spine which it may use in one of three different ways: as a goad to drive out an active insect (without necessarily touching it): as a spear with which to impale a slow-moving larva or similar creature; or as an implement (best named a poker ?) with which to push, bring towards nudge or otherwise manoeuvre an inactive insect from a crevice or hole In addition, one of Eibl-Eibesfeldt's captive birds was seen occasionally! to prise up pieces of bark—presumably using its tool as a "lever" in the full mechanical sense of the word (fulcrum, weight and power). When no longer hungry the bird would play "hide and seek" with a mealworm at its probe. Eibl-Eibesfeldt concluded from the behaviour of a young bird that an interest in manipulating sticks and probing with them was probably' an innate basis for the behaviour, the bird refining its technique by play learning. He also wrote "Tools that are not exactly fitting the purpose are worked over by the bird and thus adapted"; and Lawick-Goodall {197x) cited Bowman (1961) to the effect that one bird of this species "tried" (unsuccessfully) to break off the end of an excessively long probe, and another having twice tried to insert the forked end of a twig into a cranny broke it off at the fork and was thus able to use the implement successfully".

Lawick-Goodall (1970) concluded from this observation that "The bird may, therefore be said to show the beginnings of object modification". Later in her review of tool-using the term "object modification" appears to be used synonymously with "tool-making", and it seems clear that the way a Chimpanzee *Pan satyrus* modifies twigs is not significantly different from the way the Galapagos Woodpecker Finch does, though the frequency with which the behaviour has been observed in the wild bird is very much less than in the mammal.

Captive Galapagos Woodpecker Finches studied by Millikan and Bowman (1967) broke twigs from branches, and in a few instances a bird was seen to snap a twig into two pieces after picking it up, and to retain the shorter piece as a more manageable tool than the larger piece. Lawick-Goodall (1970) regarded even "the seemingly simple act of breaking a branch from a tree as an initial step in the modification of an object for use as a tool", provided the breaking off was done with direct reference to the problem in hand. This is clearly what the Galapagos Woodpecker Finch is doing and, taken with the fact that both wild and captive birds have been seen to modify the shape of the twig, the conclusion that this species is not only a tool-user but also a tool-maker seems inescapable.

To return now to the way the bird actually uses its tool. Millikan and Bowman (1967) did not compare their observations with those of Eibl-Eibesfeldt. They reported no instance of a captive bird using a tool as a spear or harpoon; nor did they observe its use as a goad—probably because active prey animals were not supplied. They did, however, speculate that "under natural conditions where the contents, if any, of many cracks under the bark of trees may not always be visible, the finches use tools to search for food. "Even so", the authors go on, "'none of our observations on captive or wild birds suggest that *pallida* definitely hunts with a tool; or in other words, even pick up a stick before finding a foraging site where a stick might be useful, Presumably the only precise way in which a bird can use a tool to "search for" food items that it cannot sense-experience, is by "flushing" the prey with a goad, or by exposing the prey when levering off some covering material. It is not impossible that the tool could transmit a tactile impression of an out-of-sight invertebrate i.e. by conveying the softness of a larva's body. Thus, the bird could then be said to "search for" prey in that manner. There is, however, no evidence of this and it is unlikely in any case to be important.

To describe the direct action on the prey that I have called '"poking" or prodding" Millikan and Bowman ,1967, used the verbs "lever", "?" and "slide". If by "levered" they merely meant a movement of the food directly and exclusively against the object, then strictly speaking this is not leverage since there is no fulcrum. If, however, they meant that the far end of the tool is pressed firmly on a point (thus providing a fulcrum) and that by then pivoting the stick about the point the object is moved by the tool, then true leverage is involved (as it must be when the bird pries off bits of bark). It is not difficult to image prey animals in situations from which they could not be "poked" but could only "levered" or "prised". The situation shown in the upper photograph their figure 6 would appear to be one such instance.

We thus arrive at the conclusion that with a twig in its bill a bird has a number of options. Those taken up by the Galapagos Woodpecker Finch include waving the tool as a goad, thrusting it as a spear, manipulating it as a poker and prising with it as a lever. To these Millikan and Bowman

(1967) added brandishing a twig as a weapon! They said "One of the more remarkable, and least frequent, behaviours was the use of a tool as a weapon. In one instance, a bird with a probe in its mouth moved toward another bird and drove it from the feeding tray". This incident is illustrated by frames from a 16 mm film. Bird A, using a tool to remove an insect larvae, is observed passively by bird B, when bird A swings its head round to bird B and thrusts its tool (lance ?) at bird B's breast feathers. A larger still photograph taken at a different time and depicting a bird holding a fascicle of pine needles is captioned "warding off another finch approaching the food table". Thus the bird not only wields the tool in five different ways, but to satisfy two functions: foraging and aggression.

These two authors make three other points worth quoting briefly. First, that tool-using often functions as a displacement activity; secondly, that one of the five birds that never used a tool may have failed to do so because of its isolated upbringing; and thirdly that tool-using is believed to have evolved in the Galapagos in response to an ecological factor: the dryness of the climate that causes lepidoptera and coleoptera to hide behind bark or burrow into woody tissues during daylight when the Galapagos Woodpecker Finch is hunting.

A different Galapagos finch has more recently been seen using a tool In 1964, Curio and Kramer reported that one wild individual, out of six watched, of the little-studied Galapagos Mangrove finch *Cactospiza heliobates* was seen to exhibit similar tool-using behaviour to that of the Woodpecker Finch. And Millikan and Bowman (1967) reported that another of "Darwin's Finches", a captive individual of the species *Geospiza conirostris* learnt to manipulate a twig, but never succeeded in actually using it as a tool. Hundley (1963) saw in the wild.a fourth Galapagos finch, the Warbler Finch, Certhidea olivacea holdings a 3 inch leaf-stalk with which it probed three times into a crack, and was told third-hand that a black species of Galapagos Ground Finch *Geospiza fulignosa*, and possibly *G. fortis* make use of a twig as a tool.

The report of a Victorian naturalist that an Australian species of bee-eater *Merops ornatus*, when making its nest-burrow, carried a small stick in its bill and used it as a mining tool, Chisholm (1974) thought might have been based on faulty observation.

There are three records of Australian birds using small sticks to assist in procuring food. An Eastern Shrike-Tit *Falcunculus rontatus* was seen by Richards (1971) systematically examining a dead black wattle tree. The bird broke off the end of a twig with its bill, held the 2.5-inch probe sideways and then inserted it twice into a crevice. The twig was then dropped and the bird extracted a food item. A rather similar account of a Grey Shrike-Thrush *Colluricincla harmonica* by Mitchell (1972) stated that the bird "probed the twig into the hole of a house brick that was amongst a pile of" bricks resting in my garden ... After two or three probes ... an insect crawled out of the hole and the thrush dropped the twig, picked up the insect and flew off". On one day in November 1971 Green (1972) and a colleague saw at least three (and probably more) Orange-winged Sittellas *Neositta chrysoptera* using little strips of wood as probes. How a twig was obtained was not known, but each bird wielded it with the bill and placed it under the foot while picking up the grub that had apparently been dislodged. Although the sittellas carried the twigs in their beaks along a branch while they were hopping, they always dropped them before flying.

Orenstein (1972) reports an isolated observation of possible tool-use by a New Caledonian Crow Corvus moneduloides. One individual bird was seen in ten minutes to insert a twig it was holding in its bill four times under b:ark or into the end of a hollow branch. The probing motion was always in an up-and-down direction with the bill pointing downwards. The bird was not seen to catch or to eat anything. As the author himself said, "It is difficult to speculate on such behaviour based on a single observation. I have no proof that the bird actually was foraging, nor do I have any idea how otten tool-use occurs in this species, but the repetitions of probing that I watched were similar enough to suggest that this behaviour was, if not a stereotyped pattern, at least a regularly performed action".

In North America, Brown-headed Nuthatches *Sitta pusilla* have been observed by Morse (1968) using bits of bark scale in the manner of a wedge or a lever to pry pieces of bark off tree trunks and limbs to get at insects.

On occasions the nuthatches were observed carrying single scales of bark in their beaks, though more usually they would drop the "tool" once its purpose had been served. Tool-use was noted principally outside the seasons of heavy seed crop. Thus this behaviour may be of particular use to the species in foraging when the seed crop fails. The use of tools may be confused easily with seed-cracking, which in this species is accomplished by wedging a seed into a depression of the bark and hammering upon it with the bill. When cracking seeds or other objects in the bark of long leaf pines, Brown-headed Nuthatches probably slough off scales of the flaky bark, suddenly exposing prey. The process of wedging food into a crevice is very suggestive of the way in which a flake of bark is used for a wedge and the large seeds of the long leaf pine even somewhat resemble a flake of bark. These similarities offer a possible explanation of the origin of tool-use in this species, though at present it is known only from a local population.

Also in the Nearctic, Potter (1970) studying anting behaviour in wild birds, saw a juvenile American Robin *Turdus migratorius* which held a twig in its beak and swept the ground by rotating its head through 180 degrees. The bird repeated this apparently successful attempt to locate more ants in the leaf litter several times with the same twig, thus eliminating the possibility of chance behaviour. A single instance of very similar behaviour by a Palaearctic member of the same genus, the Blackbird *Turdus merula* is given by Priddy (1977). A male bird used a twig to clear an area of snow about a foot square, presumably in the expectation of uncovering food.

Margaret Coombes (pers. comm., February 1974), following an item on animal tool-using in the BBC Animal Game programme, wrote: "A Blue Tit landed on a nut hopper hanging in my garden. In his bill he was holding a twig of about 3/4-inch long and was pushing it between the nuts in the hopper. When a nut fell through he dropped the twig and flew off with the nut"

I subsequently telephoned Mrs Coombes and she explained that the bird must have used the twig for about three minutes. The observation was made on February 17th, 1974. It is most appropriately regarded as the use of a tool as a poker or prod.

In an abstract of Millikan and Bowman (1967) in ibis 1968 110:586 K. E. L. Simmons mentioned a reliable report brought to his attention of tool-using behaviour of the sort described for *Cactospiza pallida*, by wild Blue Tit *Parus caeruleus*, adding that he hoped the record would be made generally available. Dr Simmons (pers. comm.) cannot now remember from whom he heard of the record, and to the present writer's knowledge it has not been published. As far as Dr Simmons recalls, however one individual Blue Tit was concerned and the record was well documented, the bird using items such as pine needles to obtain food. The Lawick-Goodalls (1966,1968) gave accounts of the use of tools by the Egyptian Vulture *Neophron percnopterus*, a species that exposes the contents of the Ostrich eggs by throwing stones from a standing position at the eggshell. The bird raises its head high, stone in bill, bill pointing skyward and then projects the stone in the direction of the egg with a forceful movement of the head and the neck. The stones average about five ounces in weight. The birds score hits with only about half the throws, and six to twelve direct hits are normally required to break the eggshell. Preliminary observations suggest that the impulse to throw stones is not innate but is a skill that the bird must learn for itself. The ease with which the behaviour can be experimentally induced in the wild by putting out hollow Ostrich eggs bought in curio shops has meant that it has been filmed by several cine photographers in succession to Baron van Lawick, e.g. Douglas Fisher (1970) who filmed a bird at Tendaho, Wollo Province Ethiopia.

At the time that the Lawick-Goodalls first wrote of this behaviour it was thought to be an original discovery, but as Jane van Lawick-Goodall herself later pointed out (1970, p. 199) there is a 19th century reference" the fact that the vulture uses stones to break Ostrich eggs. On "the authority of the natives about the Orange River" in south-west Africa a certain Sir James Alexander (quoted by Andersson 1856, p. 268) wrote that what the Ostriches had left their nest in the middle of the day in search of food "a white Egyptian vulture may be seen soaring in mid-air, with a stone between his talons. Having carefully surveyed the ground below him, he suddenly lets fall the stone, and then follows it in rapid descent. Let the hunter run to the spot, and he will find a nest of probably a score of eggs, some of them broken by the vulture". It would seem very likely indeed that the similar account by Wood (1877), to which attention was recently drawn by Baxter, Urban and Brown (1969), has its origin in the same account by Sir James Alexander.

A second 19th century reference has recently been brought to light by Smith (1977)- In March 1875 two sportsmen concealed near an Ostrich nest in the Sudan waiting to shoot the returning bird, saw two vultures hammering away at Ostrich eggs with stones Myers, (1876). See also Boswall (1977).

Whether "the natives about the Orange River"' actually saw Egyptian Vultures dropping stones from the sky, or whether they assumed from the simultaneous presence of stones, broken eggshell and egg-eating vultures that it was the most probable method, we do not know. The possible use by Egyptian Vultures of stones as missiles dropped from above must await critical confirmation. But in any case the story finds a striking parallel in Australia, involving a ratite bird, a bird of prey and a 19th century native account.

The possibility that the Black-breasted Buzzard *Hamirostra melanosternum* might break the eggs of the Emu *Dromaius novahollandiae* was apparently first published in 1848 by John Gould on the authority of an aboriginal account from western Australia. "This bird is so bold, that upon discovering an Emu sitting on her eggs it will attack her with great ferocity until it succeeds in driving her from them; then it takes up a stone with its feet, and while hovering over the eggs lets the stone fall upon and crush them, and then descends and devours their contents". Bennett (1881) was told by aborigines in New South Wales that the Black-breasted Buzzard, armed with a stone or a hard lump of calcined earth, approached the Emu's nest with outstretched wings, frightens the occupant off "and with the stone breaks a hole in the side of each egg into which it inserts a claw and carries them off at its leisure". A friend of Bennett's had recently found an Emu's nest with five eggs, each egg having a hole in it, and in the nest was a lump of calcined earth the size of a man's fist. Bennett himself found an Emu's nest in 1900 (quoted in North 1912) containing broken eggs, the contents of which had been devoured, and a stone which he assumed had been used to break the eggs. "The Buzzard must have carried this stone a long distance, as such a thing could not be found anywhere in the vicinity". Bennett (op. cit.) also found in the nest of one pair of buzzards, portions of Emu eggshell, and in the nest of another pair, the shells of two eggs of the Australian Bustard *Eupodotis australis*. North also quoted E. H. Lane who sent him a note from H. S. Burcher. "I have seen these birds eating Emu eggs, often breaking them; on one occasion a large bone was in the nest, and in the other a lump of burnt clay".

Casey (1966) recounted how Ostriches *Struthio camelus* were imported from South Africa into parts of Australia in the latter half of the 19th Century. One flock was kept on the Murray Downs in New South Wales where "black-breasted buzzards ... are said to have used stones to break the huge eggs... This surprising ability to use a stone as a tool in this way they acquired dealing similarly with emu eggs and with the eggs of the Plain Turkey (the bustard)"'. This was in the I880's.

Writing of the birds of a district of North Queensland, Berney (1905) recounted how he found no less than six Black-breasted Buzzards "feeding on a nest of half a dozen Emu-eggs, all broken and all fresh. In the nest... was a round -stone, the size of a domestic hen's egg, that I am sure was never put there by the Emu. Now by what means was the news of the discovery of that Emu's nest spread to gather up half a dozen of what is with us certainly a rare bird ? I would not have thought there were that number of Buzzards within a hundred miles of the place". Under the heading "Rambling Memories", Leitch (1953) wrote: "I was riding in company with the late Mr F. L. Berney, when he pointed out a pair of Black-breasted Buzzards *Hamirostra melanosterna* and told me he had actually seen them breaking emus' eggs by dropping gibbers on the nest. It seemed fantastic, and I had never heard of it before, though later the blacks confirmed it more than once.

"Less than a week later. I had the very great privilege of seeing it for myself. My attention was drawn by the actions of a pair of buzzards rising and failing over a patch of grass. I rode over to investigate and I got quite close before the birds soared away to a great height, and saw very distinctly what they were doing. Sliding down with their very distinctive flight, each picked up a stone and. flipping over the nest, dropped it. I noticed two stones had found their mark and three eggs were broken or cracked. But I also noticed that many stones had missed their mark although I doubt if they had been dropped from more than ten or twelve feet. The emus had retired and were circling a good quarter of a mile away. I would have liked to have seen the opening move, which must have meant the driving away of the parents.

"I lately saw in some nature notes a description of the rifling of an emu nest by the buzzards. It described the birds as using the stones as hammers This was not so in the above incident, for they definitely dropped the stones from the air".

Berney's published account did not refer to his having "actually seeing them breaking emu's eggs by dropping stones on the nest". It is possible that he witnessed the event after publishing his note in 1905, or that Leitch misremembered precisely what Berney had said. Leitch described himself as having been a "very small boy in the middle eighties". If we assume he was then eight, and that he wrote up his memories in 1952 he would have been about 65 years of age. Leitch's account is so specific that it is difficult to think of it as an uncritical observation, although he may have been influenced by what he thought Berney had said.

H. G. Barnard (in Campbell and Barnard 1917) records how in the Northern Territory he found a nest of the Brolga Crane *Megalornis (Grus) rubicundus* containing a single egg. "I observed a Black-breasted Buzzard soaring over the plain a short distance away. I did not disturb the egg, except to hold it up to see if it were fresh. On returning next day the nest at first sight appeared empty, but on looking closer I observed small pieces of egg-shell lying in the grass of the nest; there was also a small round stone in the nest, which was certainly no; there the day before... The stone had certainly been brought from a short distance, there being no stones in the immediate vicinity of the nest".

Chisholm (1971) quoted a charming aboriginal version of what is said to happen. It was recounted by an aboriginal housemaid employed on a district station in Western Australia. "Emu lay plenty feller big eggs. Big feller eagle want 'em. Eagle fly round an' round. Emu nothin' get up, keep alla time top of eggs. Eagle fly away old feller blacks' camp; gettem in ash-heap, make 'imself white. Fly back emu' nest. Walk up emu's nest wings like this" (spreading her arms). "Emu frightened feller. Run away Eagle pick up yabba (stone), drop 'im on emu egg. Cart 'em off longa nest quick feller. Eatem up".

To sum up. Besides the aboriginal accounts the only observations that could support the breaking open of eggs of the Emu, Australian Bustard Ostrich, or Brolga Crane by the Black-breasted Buzzard are as follows. Leitch claimed in print, many years after the event, that he had seen the buzzards dropping stones into an Emu's nest and found three broken or cracked eggs. Bennett found pieces of Emu eggshell and bustard eggshells each in buzzards' nests, and he and a friend each found a stone (or smilar object) and broken eggs in an Emu's nest. Burcher saw Emu eggs being eaten and found a bone and a lump of clay in a nest. Casey's evidences for the breaking of wild bustards' and domestic Ostriches' eggs is hearsay Berney found six buzzards consuming the contents of six Emu eggs in a nest that also contained a stone. Lastly, Barnard found pieces of eggshell and a stone in the nest of a crow (sp ?).

I have quoted and analysed the observations in some detail because, based on the same quotations, Chisholm (1954.1969,1971a, 1971b, 1972) has concluded that there is "ample evidence to indicate that a Buzzard may adapt 'shock' tactics to disturb a brooding Emu" (1971a), and that tool-using by the buzzard is an established fact. To me it seems unproven although the circumstantial evidence is perhaps strong. It is unfortunate that these alleged instances should have been so widely quoted, e.g. by Lawick-Goodall (1970), Alcock (1972), Van Tyne and Berger (1976), Wilson (1975) and others.

In the avian section of her review of tool-using by vertebrate animals, under the sub-heading "Use of stones as 'weapons' and sticks for beating" Lawick-Goodal ('1970) wrote, "Two captive Bald Eagles Haliaeetus leucocephalus (one old bird of some 35 years and the other a 2- to 3-year-old taken as a fledgling from the nest) were observed using objects aggressively on a variety of occasions. Three times the old bird took a small rock in one foot and used this to smash crickets (twice) and one giant hairy scorpion. On a number of other occassions both birds, after first trying to use their feet but being prevented by the jesses with which they were secured, picked up stones in their beak and threw them horizontally forward for distances of up to 24 inch at crickets. Several times the crickets were killed by such throws. On no occasion was the victim eaten: once a cricket was picked up in the beak but immediately shaken violently to the ground as though it tasted unpleasant "Both birds threw stones in the same manner at a tame Western Gopher Turtle—which was unharmed. Also each of the eagles once used a stick to 'beat' this turtle. The stick was held in the beak, swung upward with a dorsolateral movement of head and neck, and brought down forcefully on to the objective. These movements were repeated until the turtle moved out of reach. In view of the fact that these eagles are known to feed on turtles in the wild it is not clear exactly what these captive birds were trying to accomplish. The young eagle, when held 'on the glove', frequently picked up the ring on its chain and threw it towards its owner. This continued until the bird hit him on the arm and thus obtained his attention, whereupon it immediately ceased the bombardment".

To summarise; these Bald Eagles thus used stones in their talons as hammers, threw stones as missiles, wielded a stick held in the beak as a cudgel, and threw an object to attract attention. All four seem to qualify as tool-using. The use of tools by White-winged Choughs *Corcorax melanorhamphus* for opening fresh-water mussels *Velesunio ambiguus* was first reported by McDonald (1970). At Lake Hattah in the Hattah Lakes National Park in Victoria, Australia, he wrote, "I had often heard a light hammering sound by the lake shores, with no person in sight from which the tappings emanated. One day I decided. ...to investigate the origin of the unusual sound and this led me to discover...a large male White-winged Chough hammering away at a fresh-water mussel. The improvised 'hammer' being used was one half of an old, dry shell of the same species. It was grasped in the bird's bill, with the convex side held downwards towards the ground. The chough would stand high on his feet and bring the hammer almost vertically on to the highest spot of the mussel (the 'beak' or umbo) which is the softest part of the shell of these bivalves. Several hard blows would be made before the bird paused for a few seconds rest, only to resume the pounding again with renewed vigour. Soon a breach was made in the shell at the desired spot and, holding the mussel down with his right foot, the knowing bird began inserting its strong bill and dragging out pieces of the animal living inside".

"I had seen many of these mussel shells with holes punched in one side always at the high, soft 'beak'. These were often in heap or so and previously I had thought that the Eastern Water-rat *Hydromya chrysogaster* was responsible for them. Now it was time to attribute at least some of the breached shells to the wily choughs, the ones responsible for the fairly frequent tapping sounds along the shores of the lake. (The Park assistant, Mr G. W. Anderson, states that he actually saw a chough hammering a mussel against the butt of an empty beer bottle, but I, personally, have seen nothing to verify this.)"

Hobbs (1971) observed apparently similar behaviour, in New South Wales some 650 km distant from McDonald's locality (which was in Victoria, Australia). I will quote verbatim key extracts from

Hobbs' clear and fascinating account.

"The bird tried to open the mussel, which was held down by either foot, hammering it with the bill or trying to insert the bill between the margins of the valves. The birds often appeared impatient, running round with mussels, dropping them and picking them up, or others previously discarded.

"During this activity the birds eventually came across empty shells. Immediately, if the bird was carrying a mussel, it dropped it and picked up the empty valve. Holding it so that it pointed downwards, with the convex side away from its breast, the bird repeatedly struck the unopened mussel with it. Usually the blows- were made with a slight side-to-side movement of the head so that the mussel was struck a double blow; when broken valves were used, direct downward blows were made. The blows did not appear to be aimed at any particular part of the mussel. Occasionaly an unopened mussel was used as a hammer, also with an attempt at the double -striking blow; sometimes the target was missed: at others the bird simply dropped the 'tool' on the mussel, after holding it high with outstretched neck. The impression was that the weight of the unopened mussel was too great for them to be used effectively. During hammering, the 'tool' often broke: the chough either continued to hammer with the remaining part until it was reduced to about 10 mm in size, or picked up and used other pieces. When a valve had become useless the chough reverted to probing or hammering with the bill and, if still unable to open the mussel, picked it up and ran round until another suitable hammer was found. "During this search, the mussel was often knocked against suitable objects, such as a fallen branch, an exposed tree-root or another unopened mussel. The bird held the mussel across the middle and usually with a double stroking blow struck the posterior and anterior ends of the mussel against the anvil. Once or twice, the ventral edge of larger mussels was struck directly downward on the anvil.

"The mussels did not break or open easily. Unfortunately, because the birds were very active and the branch partly obstructed my view, I could not follow the whole process from finding to opening a mussel. One bird rained forty-two blows on one mussel before its tool completely disintegrated; it then was lost to view among the other birds. However, I saw mussels opened several times, the breach being made near the posterior or anterior end, along the ventral margin or at the umbo".

The White-winged Chough is unusual among tool-using birds in that it employs more than one technique, the use of an object held in the bill' as a hammer, and the throwing of that object as a missile. And just to enhance its versatility, it also bears its prey against an anvil (see also! Chisholm 1971b).

A delightful account by Alfred Russell Wallace (1877) from the Aru Islands is well worth quoting in detail. It concerns the Palm Cockatoo *Probosciger aterrimus* known to Wallace as the Great Black Cockatoo. The bird uses a piece of vegetation as a tool.

"It eats various fruits and seeds, but seems more particularly attached to the kernel of the kanary-nut, which grows on a lofty forest tree Canarium commune, abundant in the islands where this bird is found; and the manner in which it gets at these seeds shows a correlation of structure and habits, which would point out the "kanary" as its special food. The shell of this nut is so excessively hard that only a heavy hammer will crack it; it is somewhat triangular, and the outside is quite smooth. The manner in which the bird opens these nuts is very curious. Taking one endways in its bill and keeping it firm by a pressure of the tongue, it cuts a transverse notch by a lateral sawing motion of the sharp-edged lower mandible, This done, it takes hold of the nut with its foot, and biting off a piece of leaf retains it in the deep notch of the upper mandible, and again seizing the nut, which is prevented from slipping by the elastic tissue of the leaf, fixes the edge of the lower mandible in the notch, and by a powerful nip breaks off a piece of the shell. Again, taking the nut in its claws, it inserts the very long and sharp point of the bill and picks out the kernel, which is seized hold of, morsel by morsel, by the extensible tongue. Thus every detail of form and structure in the extraordinary bill of this bird seems to have its use, and we may easily conceive that the black cockatoos have maintained themselves in competition with their more active and more numerous white allies, by their power of existing on a kind of food which no other bird is able to extract from its stony shell". The use of the leaf material has been described by Chisholm (1971b) as an "anti-skid" device.

The account of tool-using for the purpose of body-care by a Double-crested Cormorant *Phalacrocorax auritus* by Meyerriecks (1972) is worth quoting at some length.

"Two of the cormorants were dozing while the remainder were preening and head-scratching. As I watched, one of the preening adults it would stretch its head and bill, in what seemed like an awkward manner to me, back towards its uropygial gland, squeeze the gland then apply the secretion to its wing feathers with broad sweeps or dabs of the anointed bill Suddenly, as the cormorant postured with its wings widespread, one of its secondary feathers, loosened by the moulting process, blew away from the extended wing and landed about a foot in front of the cormorant. The bird turned and stared at the feather for several moments, then it picked up the feather and held it cross-wise in its bill. It held this pose for several moments, then adjusted its grip on the feather's shaft so that the object was held almost parallel with the bill. The cormorant then deftly applied the tip of the feather to the preen gland by simply turning its head and extending the feather towards the gland. Next, the cormorant used the feather as a brush by applying the preen gland secretion to its extended right wing, doing so by making side to side sweeps with its head, the bill still holding the shaft of the feather. The sweeping brush-like motions were made smoothly and unhurriedly.

"The bird continued this behaviour, making three sets of such sweeping motions over its extended wings, once on the right wing, twice on the left, each sweep preceded by an application of the secondary feather tip to the preen gland. The gland was not manipulated by the bill after the feather had been grasped the first time. At no time did the cormorant modify the tool so as to render the 'brush' a more efficient tool.

"A passing motorboat startled the cormorants and the tool-using bird opened its bill slightly; a light easterly breeze wafted the secondary feather from the bird's bill to a place about a foot to the cormorant's left. The bird stared at the feather for a few moments, reached out and picked it up and manipulated it for a few moments more. Then the bird released the feather and the breeze carried it out over the bay to a point about 20 feet from the tool-user. The bird made no effort to retrieve its tool, and further observation of the tool-user and the other cormorants failed to reveal any further tool-using".

In this instance the bird was using one of its own body products, a feather, to attan a goal in what seemed to the author, to be an easier performance than its typical preening and oiling behaviour".

To be concluded;

REQUEST FOR FURTHER RECORD S OF TOOL-USE BY BIRDS

Readers of AVICULTURAL MAGAZINE who know of additional published references to tool-use by birds, or who can contribute unpublished observations, drawings or photographs are invited to send them as soon as possible to Jeffery Boswall, Birdswell, Wraxall, Bristol , Britain. Some aviculturists may even be tempted experimentally to offer objects to their birds. In particular it would be interesting to induce in Palm Cockatoos tool-use as observed in the wild by Alfred Russell Wallace.

TOOL USING BY BIRDS AND RELATED BEHAVIOUR

By Jeffery Boswall (Bristol)

(Concluded from page 159)

True tool-users in the wild (continued)

That the Satin Bower-bird *Ptilonorhynchus violaceus* might rank as an avian tool-user was first tentatively concluded by Gannon (1930) who noticed that a male of the species held a "bark-wad" in its bill while working at its bower. This use of "a tool to assist in painting his bower with a suspension of chewed charcoal in saliva" is referred to by Marshall (1954) who continued "Many people have since observed this remarkable: phenomenon. Some—but apparently not all—males collect fragments of fibrous bark, manipulate them with the beak and so manufacture a small oval pellet which measures about 10 x 6mm and 4mm thick. This not a brush. It seems to be a kind of combination sponge, wedge and stopper which is held almost wholly within the beak somewhat towards the distal extremity. The pellet keeps the beak slightly open as the bird jabs at, and paints, the individual twigs with the sides of its beak. It acts also as a sponge to help retain the liquid while this operation takes place." The action of the stopper on the bower is not direct (see colour photograph in Marshall 1960) and this was held by Millikan and Bowman (1967) to disqualify the bird as a true tool-user, but Chisholm (1954) and Lawick-Goodall (1970) expressed contrary views. It seems to me to be a valid case.

While all but one of the other avenue-building bower-birds are known to paint their bowers, none appears to have been recorded using a tool in the process (C. B. Frith, pers. comm. and, e.g. Peckover 1969).

Armstrong (1947) refers to the Red-faced Cisticola *Cisticola erythrops* and other warblers (no doubt including the Singing Cisticola *Cisticola cantans*) as tool-users, but these merely build nests of the tailor-bird type (Mackworth-Praed and Grant, 1955).

Discussion

The first and most obvious point to be made is that tool-using in birds is rare. Out of about 8,600 living species, the behaviour is known from only twenty-six. Further research may reveal more; there are no records so far from the mainland Neotropics, the richest zoogeographical region for birds. Of the two dozen tool-users, eight have been observed using tools only in captivity. And of the remaining eighteen free-living implement-wielders ten have been seen using a tool on only one occasion. This leaves the Black-breasted Buzzard whose egg-breaking proclivities require confirmation, and seven other birds that probably or certainly use tools with some frequency in the wild. These are: the Egyptian Vulture, Palm Cockatoo, White-winged Chough, Satin Bower-bird, Brown-headed Nuthatch, Orange-winged Sittella, and Galapagos Woodpecker Finch.

Two species not only use tools but modify them in ways that merit the term tool-making: the Northern Blue Jay and the Woodpecker Finch. The making of tools is otherwise confined to man and a few non-human primates such as the Chimpanzee.

Detailed scientific studies of these sophisticated avian behaviour patterns have been made only of captive Northern Blue Jays and Wood-pecker Finches and wild Egyptian Vultures and Brown-headed Nuthatches.

Thus our overall knowledge of even the twenty-six birds known to display these unusual propensities is slight.

Nevertheless the range of tools used and the spectrum of functions those tools serve are both quite wide. Birds compare surprisingly well with mammals in this respect, even including the non-human primates, or a survey of mammalian tool-use see Lawick-Goodall (1970) (to which Campbell (1977) adds an interesting record of a horse raking snow with stick). For the repertoire of weapon and tool use of the Chimpanzee, which uses the objects of its environment as tools to a greater extent than any other living animal except Homo sapiens, see Lawick-Goodall (1971). Incidentally the only other tool-using vertebrate is the Archer Fish *Toxotes jaculatrix*. The only invertebrates with similar abilities are spiders of several genera (J. A. L. Cooke, pers. comm.) and the following insects: solitary wasps of the genus *Ammophila*, ant lions *Myrmeleon* sp. and worm

lions of the genera *Lampromyia* and *Vermilio* (Alcock 1972, Wilson 1975); also the ant *Aphaenogaster rudis* (Fellers and Fellers 1976).
The bird species held to be true tool-users are grouped by tool-function below. The sequence of species in each group is systematic by families.

Feeding (finding, opening, moving food)	Bald Eagle (captive)
	Egyptian Vulture (wild)
	?Black-breasted Buzzard (wild)
	Palm Cockatoo (wild)
	New Caledonian Crow (wild)
	Northern Blue Jay (captive)
	White-winged Chough (wild)
	Blue Tit (wild)
	Brown-headed Nuthatch (wild)
	Orange-winged Sittella (wild)
	Eastern Shrike-Tit (wild)
	Grey Thrush (wild)
	American Robin (wild)
	Blackbird (wild)
	Galapagos Woodpecker Finch (wild and captive)
	Galapagos Mangrove Finch (wild)
	Galapagos Ground Finch sp.? (wild)
	Galapagos Warbler Finch (wild)
Drinking	Lesser Sulphur-crested Cockatoo (captive)
	"Cockatoo" (captive)
Play	African Grey Parrot (captive)
	Kea (captive)
Body care	Double-crested Cormorant (wild)
	Bare-eyed Cockatoo (captive)
	Lesser Sulphur-crested Cockatoo (captive)
	African Grey Parrot (captive)
	Blue-fronted Amazon Parrot (captive)
	Striped Owl (captive)
Display	Satin Bower-bird (wild)
Aggression	Bald Eagle (captive)
	Galapagos Woodpecker Finch (captive)
Sociality (attention-attracting)	Bald Eagle (captive)

To sum up, the true tool-users are grouped below according to the nature of their tools :

Goad	New Caledonian Crow (wild)
	Orange-winged Sittella (wild)
	Northern Blue Jay (captive)
	Eastern Shrike-Tit (wild)
	Grey Thrush (wild)
	Galapagos Woodpecker Finch (wild)
	Galapagos Mangrove Finch (wild)
	Galapagos Warbler Finch (wild)
	Galapagos Ground Finch sp. ? (wild)

Poker	Blue Tit (wild)
	Galapagos Woodpecker Finch (wild and captive)
Lever (or crowbar)	Brown-headed Nuthatch (wild)
	Galapagos Woodpecker Finch (wild and captive)
Spear (or harpoon)	Galapagos Woodpecker Finch (captive)
Lance	Galapagos Woodpecker Finch (captive)
Rake	American Robin (wild)
	Blackbird (wild)
Cudgel	Bald Eagle (captive)
Hammer	Egyptian Vulture (wild)
	Bald Eagle (captive)
	White-winged Chough (wild)
Baler	Lesser Sulphur-crested Cockatoo (captive)
	"Cockatoo" (captive)
	African Grey Parrot (captive)
	Kea (captive)
Brush	Double-crested Cormorant (wild)
	Bare-eyed Cockatoo (captive)
	Lesser Sulphur-crested Cockatoo (captive)
	African Grey Parrot (captive)
	Blue-fronted Amazon Parrot (captive)
	Parrot sp.?
Towel	Striped Owl (captive)
Sponge	Northern Blue Jay (captive)
Sponge, wedge and stopper	Satin Bower-bird (wild)
Thrown missile	Egyptian Vulture (wild)
	Bald Eagle (captive)
	White-winged Chough (wild)
	Egyptian Vulture (wild)
Dropped missile	?Black-breasted Buzzard (wild)
Anti-skid device	Palm Cockatoo (wild)
Object used to attract Attention	Bald Eagle (captive)

Birds that use tools in captivity may not do so in the wild; for example Smith (1971) suggested that individually-caged parrots of highly social species in which allopreening is particularly well developed, may have come to use scratchers as a result of their isolation. Similarly, free-living Northern Blue Jays may well not use tools, Jones and Kamil (1973) thought it a fair conclusion that their jays acquired tool-using ability while maintained under a particular set of circumstances —short rations, food pellets just out of reach and newspaper available under the cage. It is not difficult to believe that the stone-throwing and flailing behaviour of the captive Bald Eagles also arose because the birds were tethered.

What are the relative roles of instinct and learning—nature and nurture —in tool-using? It seems fairly safe to attribute individual cases in well studied species, such as the wild American Robin, Blackbird, Blue Tit and Double-crested Cormorant, to learning, either by trial-and-error or by insight learning. The same conclusion might be drawn tentatively in regard to most captive eagles and psittacids, only one of which is known to use instruments in the wild and whose behaviour in confinement is probably attributable to the special conditions. The "towel" using owl is a puzzling case, and it is hardly possible at present to comment meaningfully on such comparatively little-studied birds as the six Australasian species (parrot, crow, chough, Australian nuthatch, shrike-tit and thrush) and three of the Galapagos finches.

This leaves us with the unproven case of the Black-breasted Buzzard, with the Brown-headed Nuthatch and the Satin Bower-bird, and with the experimental studies of wild Egyptian Vultures and captive Galapagos Woodpecker Finches.

Morse (1968), student of implement-wielding Brown-headed Nuthatches, offered no opinion as to the basis of his birds' behaviour. Marshall (1954) considered the construction and painting of bowers to be heritable. The work of Jane van Lawick-Goodall on the vultures was not specifically designed to establish whether stone-throwing was inherited or acquired, but she did conclude that it was the normal response of many of the birds to egg-shaped objects that could not be picked up, even when they were larger than any living bird's egg and even when they were red or green! She expressed the intention to rear a young bird away from its kind to find out if the impulse is inborn. "We feel quite sure it is not" she wrote (1968), "for once we saw a young Egyptian Vulture try for 30 mins. to peck open an Ostrich egg. When he gave up, an even younger bird moved in, picked up a stone, and broke the egg in six minutes".

The twig-probing technique of the Woodpecker Finch was considered by Eibl-Eibesfeldt (1964b) to be an innate behaviour pattern the successful application of which, however, required refinement by learning. A male bird he acquired when it was quite young did not develop the skill fully at first. It searched for sticks, probed in crevices and holes, but only in a playful manner after feeding. When it saw an insect in a crack, it dropped the stick and attempted to catch it with its bill. The bird learned to use the tool for this purpose only gradually.

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FURTHER NOTES ON TOOL-USING BY BIRDS AND RELATED BEHAVIOUR

By Jeffery Boswall (Bristol)

Boswall, J (1978). Further notes on tool-using by birds and related behaviour. Avic.Mag. 84: 162-166.

Since the publication of my three-part paper on this subject (Boswall 1977) further observations and references have come to light.

Borderline cases in wild and some captive birds

Writing under the heading "The apparent use of rocks by a Raven is nest defense" Janes (1976) describes an incident he and a companion experienced as they were climbing down a 20m cliff after inspecting an occupied nest of *Corvus corax* in a cliff opening. "We started our descent and were 4 and cm below the nest when both ravens staged an extremely vociferous attack approaching within 3m of us. The two birds then took up positions on the cliff top 13m above us, still calling loudly. One bird stationed itself at the top of the opening. "As soon as we resumed our descent, a rock the size of a golf ball fell past my face and landed next to my feet. We assumed that it had accidentally been kicked loose by the raven. However, when we looked up,at both saw a raven with a rock in its beak perched at the top of the opening on the opposite side. With a slight flip of its head the raven tossed the rock down and across the opening towards us. From what shelter we could find, we watched the raven toss six more rocks from its position it the cliff top. One of these rocks struck me on the lower leg. The largest rock was 8 cm in diameter and 2.5 cm thick, and marks on it showed that it had been partially buried.

"When we returned later that day to photograph this behaviour, the ravens immediately flew at us and called. Again, one stationed itself in the same place at the top of the opening, but apparently no more rocks were available as only grit was thrown." This case is borderline in my opinion because the behaviour could have been a displacement activity. To the list of birds known to drop hard-shelled food items from a height must be added three species. A free-flying but captive Raven (K. Lorenz personal communication and quoted by Lawick-Goodall, 1970) frequently dropped bones in order to break them and so to feed on the marrow. The Bald *Eagle Haliaeetus leucocephalus* (C. Bindner quoted by Lawick-Goodall, 1970) has been seen to drop tortoises or turtles, and the Golden Eagle *Aquila chrysaetos* to drop tortoises (Fischer et al., 1976 77).

The Green Heron *Butorides virescens* that fished with bait (Sisson 1974) has been filmed by Paling (1978).

Lawick-Goodall (1970) also quotes a case observed by Kooij and van Zon of two captive Crested Seriemas Cariama cristata that broke hens' eggs by dropping them on to the ground. When presented with a lime egg both birds first dropped it as usual and then carried it to an anvil and dropped it on that When this was unsuccessful a definite throwing movement appeared for the first rime. John Yealland wrote to me of a Crested Seriema at the London Zoo that on being given a coin would take it to a place on the concrete or to a branch lying on the concrete and throw |t down with considerable force. "We offered it molluscs (mussels if I remember rightly), dead mice and a small snake but it did not treat any of them in this way." The action "seemed a careful and precise aiming and throwing. The bird certainly seemed to be trying to 'break open' the coin".

Lawick-Goodall (1970) describes some preliminary experiments with captive seriemas. Two birds wtre presented successively with the egg of an Ostrich *Struthio camelus*, a rhea, presumably *Rhea americana*, and a goose. Both birds after pecking and clawing at the Ostrich egg picked up one stone each. These were dropped on to the ground quite far from the egg. During the second experiment (with a rhea's egg) one seriema picked up a stone and threw it at the ground. On the third testing neither bird picked up a stone but on the fourth and last testing, with the goose egg, one bird picked up a stone, carried it to a large "anvil" rock and threw its stone at it. It would be interesting to know whether wild seriemas open rhea eggs in the wild after the manner of Egyptian Vultures Neophron percnoptnus breaking into Ostrich eggs.

To the list of birds that use anvils must be added the Blue Whistling Thrush *Myiophoneus caeruleus*. Smythies (1953) says of its diet "hard shells are a favourite item, and large heaps of fragments are often found where the shells have been broken to pieces against a rock".

True tool-users in captivity

Peter J. Olney, Curator of Birds for the Zoological Society of London, wrote of tool-using by an Oystercatcher Haematopus ostralegus. "I thought you might be interested in an Oystercatcher we had here which consistently used a lolly stick! This it held in its beak and inserted one end into the cracks in the cement surrounding the pool, presumably to dislodge food—probably invertebrates. I only actually once saw it catch an insect which it managed to persuade to leave the crack. The bird had been brought into the collection with an injured wing and seemed to develop the habit after being here some years. Presumably the number of lolly sticks is likely to be greater inside the Zoo than in its natural habitat!"

L. Gibson of New Westminster, British Columbia, Canada, wrote of a tool-using Pekin Robin. "A 1974 aviary-bred Pekin Robin Leiothrix lutea hen had been kept indoors all winter, along with a wild-caught bird. They were released into a small planted flight on 15th April 1978. The birds immediately began to bathe. The hen wet herself a little then flew up into a vine (thought to be a species of Actinidia). This vine had soft new shoots 3-4 inches (7-10 cm.) long, with about six half-sprouted leaves. The hen snapped off a shoot and began to scrub herself vigorously with it. The shoot soon broke up and she continued to rub herself with smaller pieces of leaf until it disintegrated. She repeated the whole procedure several times. This action was not seen, again and she bathes daily in the normal manner. The cock bathes normally and never attempted to use a shoot. Six years' close observation of Pekin Robins have not revealed the above action by any other individuals. This particular hen never saw her parents or any other birds do this, as far as I know. She has been under close scrutiny since birth (and has never left the premises), and was seen to do this for the first and only time at exactly four years of age."

James B. Reid (1978) gives an example of tool-use by the Rook *Corvus frugilegus*. A young captive bird was observed inserting a plug into one of six plug holes in an aviary in order that water from a constant source accumulated on the aviary floor. This water was then used by all four captive Rooks in the aviary for drinking and bathing.

In the earlier paper reference was made to a cockatoo that "would use the empty shells of monkey nuts to scoop up water when this was too low in its water-pot to be within reach of its beak". I commented that it wa» not clear whether the bird used its foot or its beak but suggested that it was more likely to have been the bird's foot. I am now glad to quote the following comment from Derek Goodwin. "I think this would be remarkable if it baled with the baler in the foot. I think I'm right in saying that parrots do not pick up objects in their feet. They pick up an object in the bill, then move the foot to the bill and grasp the object while the bill manipulates (or billipulates) it. Mice and squirrels don't pick up food in their paws either but always with the mouth, then sit back and bring paws up to mouth to hold the food".

Campbell (1977) quotes a John Ronan of Co. Wexford, Eire, whose 23-year-old African Grey Parrot Psittacus erithacus holds a crust of bread or a piece of bone in her claw and gently rubs her crown with it. The bird also rubs the feathers on her neck "the wrong way up" from her back towards the top of her head.

True tool-users in the wild

F. Duvall (personal communication, 1978) saw tool-using in three instances by two different Common Crows *Corvus brachyrhynchos* in North America in the fall of 1976. One was a wild bird, the other a free-ranging bird hand-reared in captivity. The two behaved similarly. Each held under its foot a nut of the scarlet oak *Quercus rubra* and then reached for a stone which was then used as a hammer to smash the acorn.

A different kind of tool-use by the same species was induced in captive birds by Powell and Kelly (1977). The following is taken from their abstract:

"Four common crows (Corvus brachyrhynchos) were trained to peck a key for food reward. When consistent responding developed, a metal screen was placed over the response key so that the crow could still see but could no longer peck the key. At the same time, a number of wooden matchsticks, which could be used to operate the key, were placed in the test chamber. The crows did not use the matchsticks as tools during 50 to 75 hours of exposure to this situation. Next, the crows were trained to use the matchsticks as tools to operate the key. This was accomplished by rewarding behaviors which came successively closer to the desired response (shaping) for two of the crows. Shaping was ineffective for the other two birds. However, these birds were successfully trained through gradual changes in the position of a tool (metal rod) in the test chamber (positional fading). Once tool using was established, the response readily generalized to the use of other objects, such as nails and paper clips, as tools. The crows also showed innovative behavior, in that they persistently wedged the tool (matchstick) between the edge of the response panel and the key, so that it acted as a lever. In this position, they had only to peck the tool in order to operate the response key, which produced food more rapidly and efficiently."

C. W. Benson kindly drew my attention to two additional published references to Egyptian Vultures battering with stones eggs of the Ostrich. In an article in the King William's Town (Cape Province) newspaper The Kaffrarian Watchman (the issue of 7 October 1867) by "An Old Sportsman" from Vitkyk, Namaqualand, there is a discussion of prcdation on Ostrich nests (Skead, 1971). The key paragraph reads as follows: "But what destroys the eggs most is the witte krrai (a vernacular name at that time for the Egyptian Vulture). It will take a stone as large as a cup, and let it fall on the eggs repeating this until he breaks some of them. I declare positively that I have seen him do so. I know he does it often, as in most old nests you will find a stone or two. It takes the stones from sometimes as far as about three miles. I know this because he could not get the stone nearer, being all sand. The bird will not come back to the nest if an egg is broken."

The second record was quoted by Skinner (1972) from Lindblom (1920, p. 329). The latter, writing of the natural history knowledge of the Wakamba tribesmen of East Africa, wrote: ". . . certain birds of prey— I have forgotten which—are said to be very keen on ostrich eggs. But as they are often unable to peck a hole in them with their bills, they take stones in their claws and let them drop on the eggs, thus cracking them ..." It seems very probable that the birds would have been Egyptian Vultures and that they used not their feet but their bills. In a later article, which I also overlooked, van Lawick-Goodall (1969) describes some experiments with tool-using Egyptian Vultures and mentions that this behav'iour was observed at Amboseli in Kenya and at Olduvai Gorge in Tanzania as well as at the original site, the Ngorongoro crater in Tanzania.

Discussion

Tool-use by the Oystercatcher, Pekin Robin, Rook and Common Crow raises the number of avian implement-wielders from 26 to 30.

The Oystercatcher was using a goad to find food and the Crows a hammer to open food items and a lever to gain food in the mental situation. The Pekin Robin was clearly engaged in body care, but quite what noun should be used to describe its cleaning utensil is difficult to decide —"loofah" perhaps? The Rook was using what can only (and scientifically) be described as a bath plug!

REQUEST FOR FURTHER RECORDS OF AVIAN TOOL-USE

Readers knowing of other published references to tool-use by birds or who can contribute unpublished observations, drawings or photographs are particularly asked to send them to Jeffery Boswall, Birdswell, Wraxall, Bristol BS19 1JZ, Britain.

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TOOL-USING AND RELATED BEHAVIOUR IN BIRDS: YET MORE NOTES

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Since the publication of my last paper (Boswall, 1983) further observations have come to light. This is the fourth paper in the series (Boswall, 1977, 1978, 1983).

Borderline cases in wild and captive birds

As regards species of birds dropping hard-shelled objects to break them open, a further record of Golden Eagles *Aquila chrysaetos* dropping tortoises, this time in Israel, is given by Leshem (1979). As long ago as 1905 Reiser (p. 367) reported that tortoises were dropped in Greece by Golden Eagles and were an important part of their diet (p. 369). Varshavsky(1968) confirms both these points for eagles in the Ust Urt desert of Turkmeniya in the USSR. Leshem (pers. comm., September 1982) has also observed an Egyptian Vulture *Neophron percnopterus* dropping a tortoise, this is a first record. So too is the same author's note (Leshem. in preparation) of an Osprey *Pandion haliaetus* dropping conch shells in Israel.

Two detailed studies of food-dropping behaviour are those of Beck (in press) on the Herring Gull *Larus argentatus* and of Zach (1979) on the Northwestern Crow *Corvus caurinus.*

Yet another case of baiting by a Green Heron *Butorides virescens* has been reported from the southern USA. This time the bird fished with Mayflies.

Keenan (1981) writes: "At 1815 EDT on 16 August 1975 at Lake Murray near Chapin, South Carolina. I saw a Green Heron standing on a rock at the edge of the water about 120 feet from where I stood. Behind the heron and 2 yards back from the water. a swarm of mayflies was circling. While I watched through binoculars, the bird walked to the insects, caught one, and, holding it crosswise in its beak, returned to the water where it dropped the mayfly in the shallows. A small fish rose to the fly and was caught by the heron. Four of us watched as the bird repeated the process. After catching a third mayfly, the bird went to a different perch by the water and was hidden from our view by a large boulder. The heron flew away a few moments later." Mr. Keenan tells me in a letter that the bird was a young Green Heron.

Another individual of this species, watched in Africa, in Upper Volta on 10th May 1981, dropped a flower on the water surface in a way and in circumstances that left the observers unanimous in the view that the bird was attempting to lure fish with dummy bait (Walsh and others, in preparation).

On 26th and 27th January 1983 in the Niger Republic a Green Heron was seen to lure and successfully capture a fish with an object (possibly a beetle) placed on the water (op. cit.).
In Western Australia a Black Kite *Milvus migrans* (Roberts, 1982) was seen to pick up a piece of bread from the bank of a river, drop it into the water and then fly to a perch from which it then dived - unsuccessfully-upon fish that had been attracted. The whole performance was twice repeated but still without success. The bird did catch a crayfish (a cherapin) but one which rose to the surface well away from the floating bread.Although the use of the bait was not demonstrated, in that the bird was not seen to catch a baited fish, there can be little doubt about the purpose of the behaviour.
Douthwaite (pers. comm., August 1979), who has studied Pied Kingfishers *Ceryle rudis* in Africa, reacted to the record of the bird reported earlier that baited fish with bread (Boswali. 1983) as follows: "The behaviour of the Hunter's Lodge Pied Kingfisher is the functional development of behaviour which, until now I had assumed was play. I have frequently seen kingfishers usually juveniles - pick up twigs, leaves or dead fish from the surface of the water toy with them in. the air or at a perch and then drop them again. Sometimes they have immediately dived after the object and repeated the process, but on other occasions they gazed down intently for some time before losing interest. I sometimes felt the length and intensity of that gaze, at an object deliberate dropped, was somewhat overdone. but if fish were attracted to the object then it is understandable. However, I never saw a kingfisher dive in after dropping an inanimate object and come up with a live fish."

To the list of birds that use anvils upon which to break hard-shelled prey must be added pittas of the species *Pitta versicolor* the Buff-breasted Pitta (Hindewood.1966). *P. erythrogaster* the Red-bellied (Blue-breasted) Pitta (McDonald. 1974). P. guajana the Banded Pitta (Chasen 1939) and *P. moluccensis* the Lesser Blue-winged Pitta, and P. sordida the Green-breasted Pitta (Robinson. 1927). In Madagascar the now extinct Delande's Coua *Coua delandei* was known to smash snails on anvils. Its name in the local language. Malagasy, is "Famakiakova" which means "snail axer"! Milne- Edwards, 1879). Richards (1977) implies that he saw snail bashing by the Redwing *Turdus iliacus* and confirmed to Walsh and Walsh (1983) that he twice witnessed a Redwing, perhaps the same individual, using an anvil. Walsh and Walsh (as cited) produce circumstantial evidence for the use of anvils to break open snails by the Kurrichane Thrush *T. pelios* in Upper Volta.

True tool-users in captivity

Reid's paper on the tool-using Rook *Corvus frugilegus* has now been published (Reid. 1982).
When I visited the Lincoln Park Zoo in Chicago in 1982 I was told by Kevin J. Bell that their Moluccan Cockatoo *Cacatua moluccensis* often used little twigs and other pieces of material to scratch itself. The bird also grabs one of its primary feathers with a foot, bends it (tool-making?) and uses the end to scratch under its bills and around the lower part of the head. The barbs were missing from the end of the feather.
Bruce Hoad (pers. comm. 1983) owns a Lesser Sulphur-crested Cockatoo *Cacatua sulphurea* of

the race known as the Citron-crested which scratches itself with a spoon. Ten years earlier he owned a Blue and Gold Macaw *Ara ararauna* that scratched itself with a chop bone.

A parrot of the genus Amazona, owned by Gloria Cashin (pers. comm. 1980) regularly and often scratched itself with a spoon over a number of years. It was an individually caged bird.

An African Grey Parrot known to Pamela Halford (pers. comm., l981) was naked due to an infection of the feathers and wore a specially knitted bodice. The bird would use an object, for example part of a comb, to scratch itself, apparently alleviating an irritation of the skin under the "jersey".

Janzen and others (1976) report an African Grey Parrot Psittacus erithacus that used splinters prised by the bird from the pine posts of its cage to scratch the skin on the posterior part of its head.

An African Grey Parrot *Psittacus erithacus* owned by Mrs. Rosemary Low (pers. comm. 1983) regularly scratches itself with almost any object put in its cage.

Another case of the transportation of water in a hollow object is reported by Beck (1980). "A Common Crow *Corvus brachyrhynchos* which was kept at the Allee Laboratory of Animal Behaviour at the University of Chicago was regularly supplied with various toys and trinkets for novelty. Among these was a small plastic cup. Part of the crow's diet consisted of dried mash. The laboratory assistants sometimes forgot to wet the mash slightly to make it more palatable. The crow compensated for this oversight by dipping the plastic cup in a watering trough, carrying the filled cup up to 5 metres to the food pan, and emptying the water on to the mash. This behaviour was repeated until the mash was saturated and the crow began to eat. If the water was spilled accidentally, the crow would return to the trough for a refill rather than proceed to the food pan with an empty cup".

A captive female Eclectus Parrot *Eclectus roratus* at the Brookfield Zoo. near Chicago, was seen to use a segment of palm frond to excavate a burrrow in the sand and gravel substratum of her cage. No nest-box was available and the parrot subsequently laid eggs in the burrow (Dennis DeCourcey, quoted by Beck, 1980).

Derek Wood (pers. comm. 1979), a keeper of bird at the London Zoo. had in his charge a Wedge-tailed Eagle *Aquila audax* that regularly dropped bones and other objects apparently '"on" him and their keepers in her cage. In her detailed discussion of avian play. Ficken (1977) makes it clear that birds of prey very commonly play with sticks. The attribution of tool-use to such behaviour therefore requires care. though, of course, if tool-use it be, it could have evolved from play.

True tool-users in the wild

A case of apparent tool-use by a Mountain Chickadee *Parus gambeli* is reported by Gaddis (1981). The bird was seen in Arizona and the incident described as follows: "The chickadee was foraging about seven metres up on a dead, barkless tree. It began very excitedly probing with its bill a vertical crack about one cm wide and about one half metre long. It pecked at the side of the crack and pulled off a splinter about five cm long, having a grip on the splinter about two cm from one end. It then pushed the long end of the splinter back into the crack and probed several times. It moved down the crack again and probed with the splinter once more before flying to an adjacent tree, still carrying the splinter in its bill. It held the short end of the splinter with its foot and pulled it through its bill until it had the other end in its bill. It then made several chewing movements on the splinter before discarding it and living off. I had seen nothing impaled on the end of the splinter before the Chickadee pulled it into its bill.

"Mountain Chickadees frequently excavate in decayed wood, usually flipping removed chips over their shoulder. In over 100 hours' observation of this species. this was the first time it was seen to use one of the removed pieces as a tool" It would be difficult to interpret this observation as anything other than tool-use, though the bird was not seen to succeed in any sense with the implement (Boswall, 1981).

A remarkable case of tool-use by a Grey Flycatcher *Bradornis microrhynchus* was described to me over the telephone in 1982 by Sam McNaughton. The following summarizes his observations. "In 1975 during my residence in the Serengeti National Park I twice observed a piece of bird behaviour that despite the lapse of time and the fact that I took no notes I have been strongly advised to place on record. The event was so memorable that I believe I remember the details well.

"There had been an emergence of winged termites, and the front porch of my house was littered with these animals which had by now lost their wings. A bird that I am quite certain was a Grey Flycatcher cleaned up all those that were available for the picking up. But there were others in little holes in the concrete that were apparently not accessible to the bird's bill. On each of the two days concerned one bird possibly the same individual flew to the adjacent lawn, picked up about five different grass stems in its bill in turn, and then having rejected all but one flew back to the porch with that one. The bird then poked the end of the stem into a "pit" - a spike hole- maybe 2-3 cm deep and a few mm across) containing a termite: the termite grabbed the stem and was pulled out. The stem was then put down and the termite eaten. This process was gone through eight or ten times on each day."

Tool-use by Green Jays *Cyanocorax yncas* has been observed by Gayou (1982) in Texas. He writes: "While studying this species at the Santa Ana National Wildlife Refuge near Alamo, Texas, I saw use of "tools" by a family of adult and juvenile Green Jays on 6th June 1981, I first observed an adult Green Jay (sex unknown) on the ground pick im7 a small twig in its beak and fly to a branch of a dead tree approximately -4m above the ground. The bird inserted the twig under a piece of bark and moved it back and forth for approximately 5 secs. The jay then withdrew the twig, placed it under its feet, and proceeded to consume an insect that was attached to the twig. The bird then reinserted the twig under the bark and repeated the sequence of events four consecutive times, lasting about 2 mins. The jay dropped the twig and flew a short distance to another tree. A few minutes later, the same adult Hew back to the branch with another short twig in its beak and again inserted it under the bark. This time, however, the bird prised off a piece of bark, dropped the twig, and consumed the exposed insects. Whether the jay intentionally used the twig as a lever in this instance is unknown, since this behaviour was not observed again.

"A juvenile Green Jay attempted to use twigs to capture insects in a similar manner. One of the apparent offspring (which had beer seen begging for food earlier) of the previously mentioned -adult jay picked up a twig and flew to the same branch on which the adult had been feeding. The juvenile inserted the twig several times under pieces of bark and removed it each time but did not capture arty prey item. The total time spent attempting to feed in this manner was about 45 secs. The bird then dropped the twig, flew to the ground, picked up another twig flew back to the same branch and tried again. After three unsuccessful attempts lasting about 2 mins. the bird dropped the twig and flew to another tree. Due to the inaccessibility of the branch on which the jays were feeding, the types of insects being consumed were unknown." Brook (1979) quotes two 19th century cases of crows dropping stones from a height on to eggs of the Ostrich *Struthio camelus*. The first is taken from De Mosenthal and Harting (1877) who in turn quote a paper by Atherstone (1874) in Proc. Acclim. Soc. Victoria. "'Of sixty eggs, nineteen were destroyed by black crows, which were seen from the house to hover over the nest and let stones fall on the eggs (on running up on one occasion to the nest, about 600 yards off, he (my brother, John) found three stones in the nest, the eggs cracked and the yolk strewed about". Brooke presumes that the "black crow" concerned is the Cape Raven (or Black Crow *Corvus capensis)*. Atherstone did not say whether the stones were carried in the bill or the feet. It is noteworthy that corvids are among the comparatively few kinds of birds known to drop hard-shelled objects to break them open, and that the Cape Raven in particular is known to drop small tortoises in South Africa.

The second 19th century account is by Martin (1890) who wrote of the Ostrich: "Having thus set her nest in order, she walks off, to fortify herself with a good meal for the duties of the day. And now comes the white-necked crow's chance ... An ostrich-egg is to him the daintiest of all delicacies: but nature not having bestowed on him a bill strong enough to break its hard shell, he is only able, by means of an ingenious device, to regale on the interior. He carefully watches till the parent's back is turned and she is a good distance from the nest: then. flying up into the air, he drops a stone from a great height with a most accurate aim. and breaks an egg. He makes good use of his quarter of an hour : and he no less than the hen ostrich, has had all ample meal by the time the latter returns to the nest". The "white-necked crow" is probably the Pied Crow *Corvus alba* suggests Brooke.

Beck (1980) quotes Sclater in Schaller (1974) as giving an additional instance of stone-dropping from the air by an Egyptian Vulture, in fact. it is clear that Sclater was referring to the Andersson account that he. Beck, quotes earlier in the same paragraph and to which I have referred (Boswall, 1977). Schaller (1974) says that "James Stevenson-Hamilton related in 1912 a similar incident fromthe Athi Plains Kenya". Despite quite a hard search I cannot trace this reference. Can anyone help?

Further records of Egyptian Vultures throwing stones at Ostrich eggs are reported from the Khaibar north of Eilat in Israel. Further, on 26th May (no year given) at 6.30 a.m. a vulture of this species was seen to bring a stone to a garbage dump at Sede-Boger in the Negev and drop it on to a tennis ball, presumably mistaking the tennis ball for an egg. Later other vultures standing by picked up the ball itself and dropped it on the ground - no doubt again mistaking the ball for an egg (Anon, 1980a) The throwing of rocks at eggs by Egyptian Vultures is believed to have evolved from the throwing of eggs, to smash them (Alcock, 1970).

Stone-throwing by a captive immature Egyptian Vulture is part of a public entertainment at Kintzheim in Alsace. The bird appears in an arena surrounded by scores of spectators, picks up stones, throws them at an alabaster "Ostrich" egg until it breaks and then claims the reward from inside - a lump of steak! (Martin Saunders, 16mm film for BBC Natural History Unit).

Dow (1980) gives a remarkable account of the use of primitive weaponry by wild Brush Turkeys *Alectura lathami* in Queensland, and quotes a earlier comparable case concerning a captive individual of the same species, He wrote: "Brush-turkeys visit the house regularly to feed on kitchen scraps. I have seen as many as eleven birds there at one time. Six Brush-turkeys individually marked with coloured plastic leg bands are regular visitors. The first was banded on 6th February 1974. The open vegetation and tameness of the birds makes observation easy.

"Another common resident is the Lace Monitor *Varanus varius*, which also partakes of the food supplied. I first saw a feeding Brush-turkey approached by one of these Goannas on 12 December 1976. The Brush-turkey was a large banded male; the Goanna about 1.5 metres long. As the Goanna rapidly approached the feeding site, the Brush-turkey turned his back on the Goanna and suddenly set up a barrage of sand, stones and litter with alternate powerful strokes of the legs. This halted the Goanna's advance. The Brush-turkey then turned its right flank to the Goanna aid, while watching it with more direct gaze, proceeded with a series of sideways kicks, like a logrunner. to fire quite accurately another jet of debris into the face of the Goanna. The incident lasted six minutes, during which time the Brush-turkey held the Goanna at bay. Most of the kicking was done from the left or right flank, with about seven rapid kicks between changing sides. Then the Goanna retreated, the Brush-turkey folllowed, resuming to kick sand in the face

of the Goanna when it turned towards the food.
"I thought this an interesting but isolated event until 17 March 1977, when I saw the performance repeated by an unhanded male to a different Goanna. To date. I have noted this defensive behaviour directed against Goannas by five Brush-turkeys, both males and females, on fourteen occasions. Thus it may well be a significant form of defence used by the species.

"The barrage of litter and debris and its effectiveness are not to be underestimated. Goannas recoiled under such attack and quickly retreated. The Goanna's behaviour was of interest too in these circumstances. Normally the tail is held straight, close to or dragged on the ground, as it is when chased by a human. As soon as a Goanna turned away from a Brush-turkey, the tail was held in a tight curl as the beast made an ungraceful exit. Once I saw a Brush-turkey peck the tip of the tail of a less careful Goanna........"

"It is interesting not only that Brush-turkeys have learned to use this defensive behaviour against Goannas but that Goannas have learned to withdraw their vulnerable appendage, which suggests that such interactions are far from rare. The Brush-turkey's use of simple but effective weaponry is startling when first encountered but on reflection not unpredictable because precisely the same motor patterns are used by these birds in building their nest mounds. Certainly over much of the Brush-turkey's range outside rainforest, goannas of this or other species would be encountered and could well be major predators of eggs or chicks dug from the mound. Thus the use of such a simple weapon could be a significant adaptation against a specialised ground predator.
"'I have been unable to find any published account of this anti-predator behaviour in wild Brush-turkeys. Fleay (1937) described a captive male that "............deliberately showered me with dirt and leaves and persisted in doing so. no matter which side of the mound I endeavoured to approach.'"
What must surely be regarded as an even more remarkable use of a weapon by a bird was recently reported (Anon. 1980b). In May 1980 in the Mivtahim region of the western Negev an adult Egyptian Vulture was seen to swoop down upon and grab in its beak a young Monitor Lizard *Varanus griseus*. The bird flew up to a height of about 100 metres and dropped the lizard which " .... was hurt but still alive. The vulture came down looked at its prey ior a moment, flew off a few metres. and returned with a stone in its beak with which it proceeded to beat the Monitor on the head till it was dead".
That a bird should drop a vertebrate animal with the apparent intention of subduing if not killing it may be without precedent in itself (though there is hearsay evidence of the Kookaburra *Dacelo novaeguineae* doing the same thing with snakes). The use of an external object as a cudgel is a rare form of tool-use in wild birds.
Montevecchi(1978) writing under the heading "Corvids using objects to displace gulls from nests'", cites two happenings as examples of tool-use. In the first case a Fish Crow *Corvus ossifragus* dropped a stalk of dried marsh grass Spartina toward a nesting gull. The object fell about 1 metre from the gull which remained on the nest. On the basis of the account given no "use" occurred, and the "intention" of the crow is hardly beyond doubt. In the second case a Raven *Corvus corax* perched about 1 metre above a Kittiwake's *Rissa tridactyla* nest, pulled a tuft of grass from the cliff face and dropped it. It fell on the gull which took flight and the Raven rummaged through the nest which was empty. Ravens at this location frequently supplant nesting Kittiwakes by suddenly approaching them closely while calling loudly, or sometimes by physical attack. In this case an object released by one bird hit another which then departed. On the basis of the one instance it is again difficult to be sure that the behaviour was not displacement activity and the effect gratuitous.

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